

Magnet coils for RHIC EBIS

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RHIC EBIS magnet coils are used for providing magnetic field for electron-optical structure guiding the electron beam and for focusing the extracted ion beam into RFQ accelerator.

The requirement to the accuracy of control and to the current stability of power supplies for all 3 coils is $\pm 0.1\%$ (pulse-to-pulse and long term, not to the flatness of the current pulse for magnet lens coil, which is 1% during 1 ms).

1. Electron gun magnet coil.

This coil is used for generating the magnetic field in an electron gun region to provide the proper conditions for electron beam forming in the vicinity of the cathode and guiding it through the anode until beam enters the field of the main solenoid.

This coils is made of a copper hollow conductor with rectangular cross-section. The conductor is double isolated with fiberglass tape. The coil winding is made of 14 “pancakes”. Each “pancake” is made of a single piece of conductor and consists of 2 adjacent flat spirals. All “pancakes are connected in series for electric current and in parallel for cooling water.

The geometrical parameters of this coil are summarized in Table 1 and operating parameters are summarized in Table 2.

| Parameter | Value |
|---------------------------------------|----------------------|
| Side of the conductor | 5.26 mm |
| ID of cooling channel | 2.87 mm |
| Cross sectional area of the conductor | 21.2 mm ² |
| Length of the coil winding | 184 mm |
| Inner diameter of the coil winding | 273 mm |
| Outer diameter of the coil winding | 453 mm |
| Number of “pancakes” | 14 |
| Number of vertical layers | 15 |
| Total number of turns in the coil | 420 |
| Total length of the conductor | 480 m |
| Inductance | 0.066 Henry |

Table 1. Geometrical parameters of the gun coil.

| Parameter | Nominal values | Maximum values |
|---|----------------|----------------|
| Coil current | 140 A | 180 A |
| Maximum magnetic field in median plane | 0.195 T | 0.251T |
| Resistance of the coil winding | 0.448 ohm | 0.463 ohm |
| Voltage drop on the coil | 62.7 V | 83.3 V |
| Power dissipated on the coil | 8.8 kW | 15.0 kW |
| Water flow through the coil | 1.5 GPM | 1.8 GPM |
| Water pressure drop | 2.45 Bar | 3.39 Bar |
| Cooling water temperature rise in a coil | 22.2 °C | 31.6 °C |
| Temperature difference between copper and water | 0.24 °C | 0.35 °C |

Table 4. Operating parameters of the electron collector coil.

2. Electron collector magnet coil.

It is wound with the same conductor as an electron gun magnet coil: insulated square conductor with side 5.26 mm and water-cooling channel ID=2.87 mm.

The coil winding is made of 10 “pancakes”. Like a gun coil each “pancake” of the electron collector coil is made of a single piece of copper conductor and consists of 2 adjacent flat spirals. All “pancakes” are connected in series for electric current and in parallel for cooling water.

The geometrical parameters of this coil are summarized in Table 3 and operating parameters are summarized in Table 4.

| Parameters | Values |
|---------------------------------------|----------------------|
| Side of the conductor | 5.26 mm |
| ID of cooling channel | 2.87 mm |
| Cross sectional area of the conductor | 21.2 mm ² |
| Length of the coil | 131.4 mm |
| Inner diameter of the coil winding | 287 mm |
| Outer diameter of the coil winding | 418 mm |
| Number of “pancakes” | 10 |
| Number of vertical layers | 12 |
| Total number of turns in the coil | 240 |
| Total length of the conductor | 260 m |
| Inductance | 0.066 Henry |

Table 3. Geometrical parameters of the electron collector coil.

| Parameters | Nominal values | Maximum values |
|---|----------------|----------------|
| Coil current | 180 A | 260 A |
| Maximum magnetic field in median plane | 0.1485 T | 0.20T |
| Resistance of the coil winding | 0.241 ohm | 0.256 ohm |
| Voltage drop on the coil | 43.3 V | 66.5 V |
| Power dissipated on the coil | 7.8 kW | 17.3 kW |
| Water flow through the coil | 1.2 GPM | 1.5 GPM |
| Water pressure drop | 2.28 Bar | 3.39 Bar |
| Cooling water temperature rise in a coil | 25.7 °C | 41.6 °C |
| Temperature difference between copper and water | 0.36 °C | 0.65 °C |

Table 4. Operating parameters of the electron collector coil.

3. Coil of the LEBT magnetic lens.

This coil is made of a single piece of insulated hollow square conductor without any current or water flow breaks. The coil has 4 layers of winding with sufficient insulation between layers. The coil is shielded with 30 mm laminated soft iron.

The geometrical parameters of this coil are summarized in Table 5 and operating parameters are summarized in Table 6.

| Parameters | Values |
|---------------------------------------|----------------------|
| Side of the conductor | 9.7 mm |
| ID of cooling channel | 7.9 mm |
| Cross sectional area of the conductor | 45.1 mm ² |
| Length of the coil winding | 307.2 mm |
| Inner diameter of the coil winding | 125.6 mm |
| Outer diameter of the coil winding | 212 mm |
| Number of vertical layers | 4 |
| Total number of turns in the coil | 120 |
| Total length of the conductor | 57 m |
| Inductance | 0.001 Henry |

Table 5. Geometrical parameters of the coil of the LEBT magnetic lens.

| Parameters | Nominal values | Maximum values |
|---|----------------|----------------|
| Coil current | 1917 A | 3000 A |
| Maximum magnetic field in median plane | 0.873 T | 1.36 T |
| Resistance of the coil winding | 0.239 ohm | 0.0251 ohm |
| Resistive voltage drop on the coil | 45.9 V | 75.2 V |
| Inductive voltage drop on the coil | 410 V | 641 V |
| Pulse length | 15 ms | 15 ms |
| Frequency | 5 Hz | 5 Hz |
| Peak power dissipated on the coil | 88.0 kW | 226 kW |
| Average power dissipated on the coil | 4.2 kW | 10.8 kW |
| Water flow through the coil | 0.87 Bar | 1.38 GPM |
| Water pressure drop | 2.28 Bar | 3.4 Bar |
| Cooling water temperature rise in a coil | 18.4 °C | 29.5 °C |
| Temperature difference between copper and water | 0.41 °C | 0.73 °C |

Table 6. Operating parameters of the coil of the LEBT magnetic lens for Au³²⁺.